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THE FUNCTIONALLY-ORIENTED METHOD FOR SPECIALIZED EI-SYSTEMS DESIGN APPLICATION

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Abstract. *The algorithm and the model of the functionally-oriented method for specialized educational and intellectual systems (EI systems) automated design, based on Petri nets, are developed in the article. The example of the developed algorithm application for the real EI-system design is also given. The developed model based on Petri nets helps to identify the major states of the system synthesis process.*

Keywords: method, model, Petri nets, design, EI system

FUNKCJONALNIE ZORIENTOWANA METODA PROJEKTOWANIA APLIKACJI SPECJALISTYCZNYCH SYSTEMÓW EDUKACYJNYCH I INTELIGENTNYCH

Streszczenie*. W artykule rozpatrzono algorytm i model funkcjonalnie zorientowanej metody projektowania automatycznego specjalizowanych systemów edukacyjnych i inteligentnych (systemów EI) opartych na sieciach Petri. Przedstawiono również przykład tworzenia algorytmu aplikacji dla rzeczywistego projektowania systemu EI. Opracowano model oparty na sieci Petriego wspomagającej identyfikację głównych stanów systemu syntezy procesów.*

Słowa kluczowe: sposób, modelu sieci Petriego, projektowanie, EI-systemy

Introduction

Development of any complex system is associated with some major difficulties. The initial design stage requires determination of the system structure, its main elements and parameters, relations among data structure elements and others. There are number of methods for the design automation at the system level [1, 5, 9, 14, 16], but one of the most effective for specialized EI systems development is the functionally-oriented method [11, 15].

Examples of such complex systems are specialized educational and intelligent systems (EI-systems), which are nowadays very popular and fast-growing. Since EI systems ensure effective support of modern training technologies [6], development of the model and algorithm for functionally-oriented method application is the relevant modern task.

1. Development of the specialized EI systems automation design algorithm

This article presents the algorithm for the functionally-oriented method application, which involves the following basic steps:
Step 1. Input data setting and defining the EI systems class.
Step 2. Selection of the EI-system functional profile [8].
Step 3. Formation of the projects that correspond to the selected (developed) functional profiles of the developed EI-system.
Step 4. Specifying of the linguistic variable "EI-system project general coefficient".
Step 5. Selection of the partial coefficients for all EI-system projects.
Step 6. Determination of the estimates for all EI-system projects partial coefficients.
Step 7. Determination of the estimate for each EI-system projects general coefficient.
Step 8. Comparing EI system projects by general coefficients and selection of the technical implementation project.
Step 9. If the project satisfies customer requirements, then the algorithm is completed, otherwise, go to step 2.

According to the developed algorithm, one or several standard functional profiles should be selected (step 2 of the algorithm) from among those, which correspond to the class specific for EI-system, which are designed according to the technical task. It is possible to develop a special functional profile or modify the standard one. During the linguistic variable (LV) "EI-system project general coefficient" introduction (step 4) all terms and the corresponding functions have to be built. When choosing partial coefficients for all EI system projects (step 5) the appropriate LV should be set and the priority coefficients should be calculated. Evaluation of EI-system projects partial coefficients (step 6) is determined by expert evaluation, calculation and analysis based on the unified software modules values that are part of this project.

The developed algorithm allows automatically implement the computer aided design method and realize the specialized EI-systems synthesis procedure.

2. The EI systems designing process model based on Petri nets

For studying of the basic states of functionally-oriented method based on the developed algorithm, the model basing on Petri net [7, 10, 13] was built, it can be described using the following expression, an example of the scheme model is in Fig. 1.

$$N = \{S, T, F, M_0\} \tag{1}$$

where: $P=\{p_1, p_2, \ldots, p_n\}$ is the set of positions (states); $T=\{t_1, t_2, \ldots, t_m\}$ is the set of transitions; F is the set of arcs, which includes two subsets of incoming and outgoing arcs in relation to transition; M_0 is the set, which specifies the initial tagging of Petri nets.

Table 1. Table of the developed model based on Petri net positions

Position	Purpose
p1	The start position. The marker in this position testifies the launch of the model.
p2	The subsystem initialization position. The marker in this position testifies successful initialization of the model.
p3	Position responsible for the chosen class of the developed EI-system.
p4	Position that corresponds to the selected functional profile of the developed EI-system.
p5	Position responsible for specifying linguistic variable "EI-system project general coefficient".
p6	Position is responsible for determining estimates for all EI-system projects general coefficients.
p7	Stage of project coordination with the customer.
p8	The marker in this position demonstrates that the project satisfies the customer requirements.
p9	Position responsible for the case, when this project does not meet the customer requirements. The marker in this position testifies choice of some other (different from the previous) EI-system functional profile and subsequent formation of the next project, which would satisfy the requirements of the customer.
p10	Model shutdown position. The marker in this position testifies completion of the developed model work.

The built model based on Petri nets contains number of states p1–p10, and number of transitions t1-t8, which have individual logically-functional purpose (see table 1 and table 2, respectively).

The positions set describes the possible model`s states and enables tracking behavior of the design process on separate areas, whereas the transitions set reflects the internal processes that occur inside the model and are designed to achieve results.

Below, in fig. 2, the corresponding states reachability graph for the developed model based on Petri net is presented [12], it allows exploring possible states and dynamics of the specialized EI systems design process.

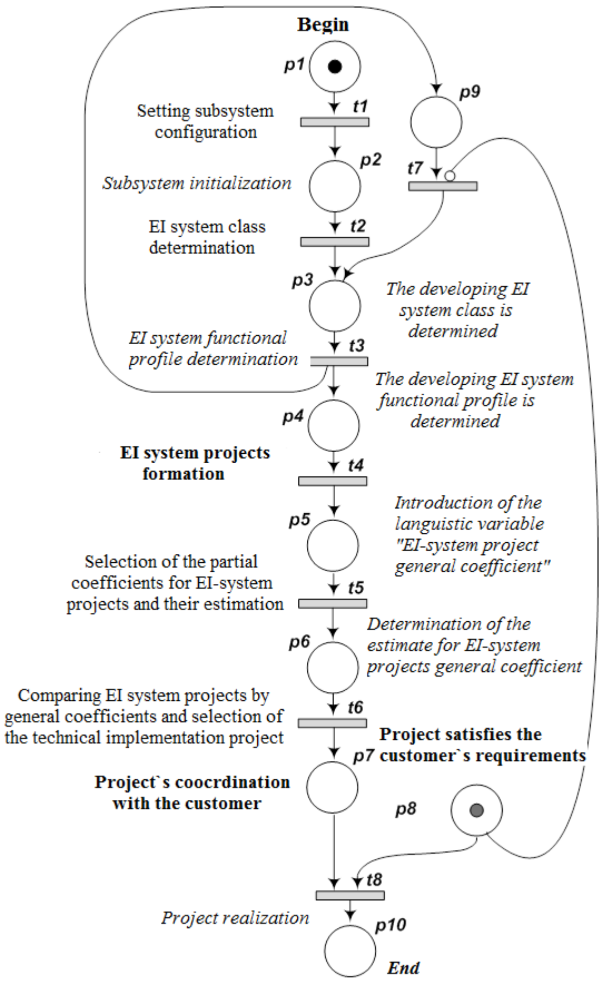

Fig. 1. The developed model based on Petri nets

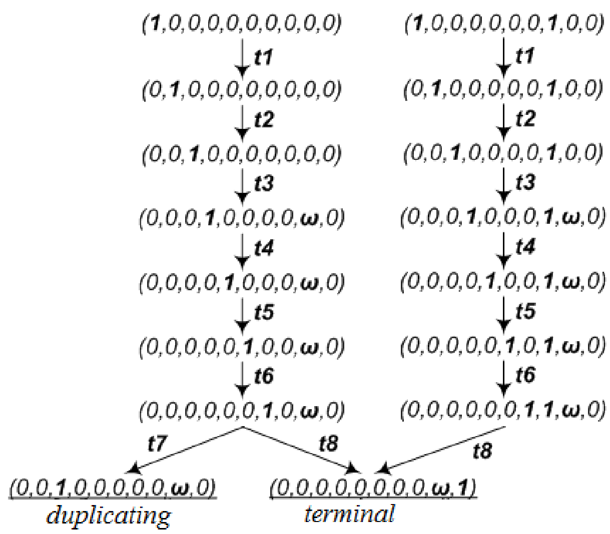

Fig. 2. States reachability graph for the developed model based on Petri nets

Table 2. The developed model based on Petri net transitions table

Transition	Purpose
t1	The subsystem configuration setting.
t2	The developed EI-system class determination.
t3	The developed EI-system functional profile choice.
t4	Formation of projects that correspond to the selected (developed) functional profiles of the developed EI-system.
t5	Choice of the partial coefficients for all EI systems projects. Determination estimates of the partial coefficients for all EI systems projects.
t6	Comparison of EI system projects by general coefficients and selection of the technical implementation project.
t7	Start of the other functional solution selection mechanism for project implementation that ensures the customer requirements.
t8	Implementation of the project. Shutdown of the model.

3. Results of the specialized EI system structure synthesis using the functionally-oriented method

To illustrate the developed method for EI system design, the following example is presented. Assume, that the EI system, which according to future plans and other considerations is referred to class "12. Context-search EI system", is being developed. Let assume, that for this class of systems there are two standard functional profiles:

$$\Phi^{c}{}_{12\,1} = \{\psi_7, \psi_{19}, \psi_{27}\},\ \Phi^{c}{}_{12\,2} = \{\psi_7, \psi_{19}, \psi_{31}\}, \quad (2)$$

where ψ_7 – "Contextual search" functional service; ψ_{19} – "Ranking of search feedback by relevance" functional service; ψ_{27} –"Automated text summarization" functional service; ψ_{31} – "Automated text annotation" functional service.

Assume that system developers have access to the standardized software modules library, which among others contains the following modules: θ_4 with $\Phi^{M}{}_4 = \{\psi_7\}$ functional profile, θ_9 with $\Phi^{M}{}_9 = \{\psi_7, \psi_{16}\}$ functional profile, θ_{41} with $\Phi^{M}{}_{41} = \{\psi_{19}\}$ functional profile, θ_{45} with $\Phi^{M}{}_{45} = \{\psi_{27}\}$ functional profile, θ_{68} with $\Phi^{M}{}_{68} = \{\psi_{31}\}$ functional profile. Here ψ_{16} is "Automatic correction of the search query spelling" functional service. Thus, in accordance with the proposed methodology for the developed system implementation the 4 following projects might be formed:

$$\Omega_1 = \{\theta_4, \theta_{41}, \theta_{45}\},\ \Omega_2 = \{\theta_9, \theta_{41}, \theta_{45}\},$$

$$\Omega_3 = \{\theta_4, \theta_{41}, \theta_{68}\},\ \Omega_4 = \{\theta_9, \theta_{41}, \theta_{68}\} \quad (3)$$

(since this example illustrates design procedure for only one EI-system, p' index in the project conditional signs is excessive, so here and further on we will be limited to only ν index use).

For the optimal project selection the partial modules coefficients listed in table 3 (in table 3 and further on the letter t after shortenings VHV and HV should be read as "trustworthy") should be considered. Some partial coefficients values are presented in conventional units, the rest, primarily integrated indices are characterized by fuzzy expert estimates [2, 3, 4] for LV with five terms and changes range from 0 to 1. Limits of the according belonging functions are defined in analogy with the common criteria.

Among the Ω_1, Ω_2, Ω_3, Ω_4 projects the optimal one should be chosen, with considering that the most important system element is the context search module, thus θ_4 and θ_9 for the respective projects. The projects comparison will be done with the thought that the general quality indicator for each of them will be determined based on the following partial indicators (presented by decreasing priority): search speed w_1; search precision w_2; search completeness w_3; referencing/annotation quality w_4; ranking quality w_5; guarantability w_6 (cumulative characteristic determined by the modules reliability and quality of their license maintenance); cost of the project w_7.

The cost of the project will be considered to be equal to the sum of the included modules cost. For those projects, where only one module identifies some indicator, its value for the entire project coincides with one for indicator`s module. For other indicators their scores for the entire project also correspond to the LV in the range from 0 to 1, and for their determination the same methodology as for general project index finding should be applied. In this case, priority coefficients help to verify that various modules contribute differently to this index value.

Thus, the belonging functions of LV terms 1-6 coefficients will be defined as follows ($i=\overline{1,6}$): w_{i1} = <0; 0; 0.1; 0.2 >, that corresponds to VLV; w_{i2} = <0.1; 0.2; 0.3; 0.4 >, which corresponds to LV; w_{i3} = <0.3; 0.4; 0.5; 0.6>, which corresponds to AV; w_{i4} = <0.5; 0.6; 0.7; 0.8>, which corresponds to HV; w_{i5} = <0.7; 0.8; 1; 1>, which meets VHV.

The belonging functions of LV terms 7 coefficient equal to: w_{71} = <0; 0; 2; 3>, which corresponds to VHV; w_{72} = <2; 3; 3.5; 4>,which corresponds to HV; w_{73} = <4; 4.2; 4.5; 5>, which corresponds to AV; w_{74} = <4.5; 5; 5.3; 5.5>, which corresponds to LV; w_{75} = <5.3; 5.5; ∞; ∞ >, which corresponds to VLV.

Table 3. Parameters of the unified software modules

Module	Parameter	Parameter value
θ_4	Search speed	VHV T 0.8 .
	Search precision	VHV T 0.8 .
	Search completeness	HV T 1 .
	Reliability	HV T 0.7 and VHV T 0.3_.
	Cost	1800 $
	License terms	AV t 1
θ_9	Search speed	HV T 0.9 .
	Search precision	HV T 0.9 and VHV T 0.1_.
	Search completeness	VHV T 0.6 .
	Reliability	AV T 0.6 and HV T 0.4 .
	Cost	1400 $.
	License terms	LV T 1.0 .
θ_{41}	Ranking quality	HV T 0.4 and VHV T 0.6_.
	Reliability	HV T 0.6 i VHV T 0.4_.
	Cost	1000 $.
	License terms	LV T 0.4 and AV T 0.6 .
θ_{45}	Summarizing, annotation quality	HV T 0.7 and VHV T 0.3_.
	Reliability	AV T 0.9 and LV T 0.1 .
	Cost	2200 $
	License terms	VHV T 0.6 .
θ_{68}	Summarizing, annotation quality	VHV T 0.8 .
	Reliability	AV T 0.9 and LV T 0.1 .
	Cost	1800 $.
	License terms	LV T 1

Lets find the guarantebility index value w_6. First of all we have to determine the reliability f the each project (w_8) and quality of the license maintenance by the modules developers (w_9). For each term of the same content (VLV, LV, AV, HV, VHV) we will get the estimates:

$$x_j = \sum_k B_k \mu_{k\,j}(w_k)\,. \tag{4}$$

For example, Bi coefficients will be got with the use f Fishburn method:

$$B_k = \frac{2(T+1-l_k)}{T*(T+1)}, \tag{5}$$

where lk – number of k-th module in the order of its importance in the project`s appropriate metric, T is the total number of project modules.

Let the module θ_4 be more important for the w_8 coefficient, than the module θ_{45} but module θ_{45} is more important, than θ_{41} one. According to formula (5) the corresponding modules priority coefficients will be computed:

$$B_1 = \frac{2(3+1-1)}{3*4} = \frac{1}{2}; \quad B_2 = \frac{1}{6}; \quad B_3 = \frac{1}{3}. \tag{6}$$

Then the following data will be got for the project Ω_1 table 4).

The estimation of the Ω_1 project generalized reliability index w_8 will be done by the following formula:

$$w_{18} = \sum_{j=1}^{5} x_j E_{\alpha\,j} = 0*0.05 + 0.0333*0.25 + \\ + 0.3*0.45 + 0.45*0.65 + 0.216*0.9 = 0.633. \tag{7}$$

When w_{18} = 0.633 the project reliability Ω_1 corresponds to the HV term with the belonging function μ_4 (0.633) = 1 and for all other terms with the belonging function equals zero.

In the same way the reliability indicators for four other projects will be found. For the project Ω_2 the situation is the following:

$$w_{28} = \sum_{j=1}^{5} x_j E_{\alpha\,j} = 0*0.05 + 0.0333*0.25 + \\ + 0.6*0.45 + 0.3*0.65 + 0.067*0.9 = 0.533\,. \tag{8}$$

Table 4. Data for the first project reliability index calculation

Module	w_8 index terms				
	VLV	LV	AV	HV	VHV
θ_4	$\mu_{11}=0$	$\mu_{12}=0$	$\mu_{13}=0$	$\mu_{14}=0{,}7$	$\mu_{15}=0{,}3$
θ_{41}	$\mu_{21}=0$	$\mu_{22}=0$	$\mu_{23}=0$	$\mu_{24}=0{,}6$	$\mu_{25}=0{,}4$
θ_{45}	$\mu_{31}=0$	$\mu_{32}=0{,}1$	$\mu_{33}=0{,}9$	$\mu_{34}=0$	$\mu_{35}=0$
$x_j = \sum_{i=1}^{3} B_i \mu_{ij}$	0	0,0333	0,3	0,45	0,216

For the project Ω_3 - w_{38} = 0.672, and for Ω_4 - w_{48} = 0.586.

The value of modules quality license maintenance indexes are found the same way, namely: w_{19} = 0.554, w_{29} = 0.451, w_{39} = 0.39, w_{49} = 0.495.

In case of the equal importance of the indicators w_8 and w_9 ($B_1 = B_2$ = 0.5) for the guarantability indicator w_6 (project Ω_1) the last will be computed based on the data summarized in table 5.

Table 5. Data for the first project guarantability index calculation

Coefficient	Terms				
	VLV	LV	AV	HV	VHV
w_8	$\mu_{11}=0$	$\mu_{12}=0$	$\mu_{13}=0$	$\mu_{14}=1$	$\mu_{15}=0$
w_9	$\mu_{21}=0$	$\mu_{22}=0$	$\mu_{23}=0.54$	$\mu_{24}=0.46$	$\mu_{25}=0$
$x_{j6}=\sum_{i=1}^{2} B_i\mu_{ij}$	0	0	0.27	0.73	0

Thus,

$$w_{16}=\sum_{j=1}^{5} x_j E_{\alpha j}=0*0.05+0*0.25+ \\ +0.27*0.45+0.73*0.65+0*0.9=0.6. \tag{9}$$

When w_{16} = 0.6 the investigated project Ω_1 guarantability corresponds to term VZ with belonging function μ_4 (0.6) = 1 and to all other terms with the function equals zero.

Guarantability indicators for the remaining three projects can be found in the same way. For the project Ω_2, accordingly, w_{26} = 0.483, for project Ω_3 - w_{36} = 0.536, and Ω_4 - w_{46} = 0.537. On the basis of all partial projects coefficients summarized in table 6, the overall index estimates will be computed. According to the partial indicators ranking order the priority coefficients Bk obtained by the Fishburn method equal to:

$$B_1=\frac{2(7+1-1)}{7*8}=\frac{1}{4};\ B_2=\frac{6}{28};\ B_3=\frac{5}{28}; \\ B_4=\frac{1}{7};\ B_5=\frac{3}{28};\ B_6=\frac{1}{14};\ B_7=\frac{1}{28}. \tag{10}$$

Results of the belonging functions for each Ω_1 project indicator calculations are given in table 7.

Table 6. Projects partial indicators

Project	EI system partial criteria						
	w_1	w_2	w_3	w_4	w_5	w_6	w_7
Ω_1	VHV T 0.8_	VHV T 0.8_	HV T 1_	HV T 0.7 and VHV T 0.3	HV T 0.4 and VHV T 0.6_	HV T 1_	LV T 1_
Ω_2	HV T 0.9 and VHV T 0.1_	HV T 0.7 and VHV T 0.3	HVT 0.4 and VHV T 0.6_	HV T 0.7 and VHV T 0.3	HV T 0.4 and VHV T 0.6_	AV T 1	LV T 0.2 and AV T 0.8_
Ω_3	VHV T 0.8_	VHV T 0.8_	HV T 1_	VHV T 0.8	HV T 0.4 and VHV T 0.6_	HV T 0.36 and C3 T 0.64	LV T 0.2 and AV T 0.8.
Ω_4	HV T 0.9 and VHV T 0.1	HV T 0.7 and VHV T 0.3_	HV T 0.4 and VHV T 0.6	VHV T 0.8	HV T 0.4 and VHV T 0.6.	HV T 0.36 and AV T 0.64	AV T 1

Table 7. The first project partial indicators belonging functions

Indicator	Terms				
	VLV	LV	AV	HV	VHV
w_{11} = 0.78	$\mu_{11}(w_{11})=0$	$\mu_{12}(w_{11})=0$	$\mu_{13}(w_{11})=0$	$\mu_{14}(w_{11})=0.2$	$\mu_{15}(w_{11})=0.8$
w_{12} = 0.78	$\mu_{21}(w_{12})=0$	$\mu_{22}(w_{12})=0$	$\mu_{23}(w_{12})=0$	$\mu_{24}(w_{12})=0.2$	$\mu_{25}(w_{12})=0.8$
w_{13} = 0.65	$\mu_{31}(w_{13})=0$	$\mu_{32}(w_{13})=0$	$\mu_{33}(w_{13})=0$	$\mu_{34}(w_{13})=1$	$\mu_{35}(w_{13})=0$
w_{14} = 0.73	$\mu_{41}(w_{14})=0$	$\mu_{42}(w_{14})=0$	$\mu_{43}(w_{14})=0$	$\mu_{44}(w_{14})=0.7$	$\mu_{45}(w_{14})=0.3$
w_{15} = 0.76	$\mu_{51}(w_{15})=0$	$\mu_{52}(w_{15})=0$	$\mu_{53}(w_{15})=0$	$\mu_{54}(w_{15})=0.4$	$\mu_{55}(w_{15})=0.6$
w_{16} = 0. 6	$\mu_{61}(w_{16})=0$	$\mu_{62}(w_{16})=0$	$\mu_{63}(w_{16})=0$	$\mu_{64}(w_{16})=1$	$\mu_{65}(w_{16})=0$
w_{17} = 5	$\mu_{71}(w_{17})=0$	$\mu_{72}(w_{17})=1$	$\mu_{73}(w_{17})=0$	$\mu_{74}(w_{17})=0$	$\mu_{75}(w_{17})=0$
$x_j=\sum_{i=1}^{7} B_i\mu_{ij}$	0	0.036	0	0.486	0.478

The overall coefficient for Ω_1 project

$$x_1 = \sum_{j=1}^{5} x_j E_{\alpha\, j} = 0 * 0.05 + 0.036 * 0.25 + \qquad (11)$$
$$0 * 0.45 + 0.486 * 0.65 + 0.478 * 0.9 = 0.755.$$

When x_1 = 0.755 the general coefficient of the investigated project Ω_1 corresponds to the term HV with the belonging function μ_4 (0.755) = 0.45 and to term VHV with the function 0.55. The general indicators for the remaining three projects can be found in the same way. For the project Ω_2 we have x_2 = 0.703 (corresponds to term HV with belonging function μ_4 (0.703) = 0.97 and term VHV with belonging function μ_5 (0.703) = 0.03). For the project Ω_3 - x_3 = 0.739 (corresponds to term HV with the belonging function μ_4 (0.739) = 0.61 and term VHV with the function μ_5 (0.739) = 0.39). For the project Ω_4 - x_4 = 0.757 (corresponds to term HV with belonging function μ_4 (0.757) = 0.43 and term VHV with the belonging function μ_5 (0.757) = 0.57. Judging from the general indicator values project Ω_4 is the best one and Ω_2 is the worst.

Conclusions

The algorithm of the functionally-oriented method for specialized educational and intellectual systems (EI systems) automated design, based on the unified software modules library and performance indicator definition model for intellectual EI-system project selection is developed in the article. It enables automation of the specialized EI systems synthesis process.

The relevant model based on Petri net, which allows exploring dynamics of the specialized EI systems developing process, is also constructed in the article

The given results of functionally-oriented method appliance to the specialized EI system structure synthesis allow arguing that the developed algorithm works correctly and ensures the optimal choice of the developing system structure.

Literature

[1] Dobrov G.M.: Ekspertnyye otsenki v nauchno-tekhnicheskom prognozirovanii, Naukova dumka, 1974.

[2] Glínenko L. K.: Tekhnologíya ínzhenernogo proyektuvannya: strukturniy sintez bíotekhníchnikh sistem: navch. posíbn, L'vívs'ka Polítekhníka, L'vív 2004.

[3] Grigor'yev V.A.: Otsenka kachestva intellektual'nykh sistem, operiruyushchikh neformal'nymi ponyatiyami, Nauka i obrazovaniye 10/2004, URL:http://technomag.edu.ru/sdocs/about.html

[4] Hamza Ali Yousef AlShawabkeh, Teslyuk V., Zelinskyy A., Denysyuk P., Bobak K.: Desreasing Alternative Solutions Multitude Power Using Branch and Bound Algorithm During Solving MEMS Synthesis Task, Proc. of the X Intern. Conf. on The Experience of Designing and Application of CAD Systems in Microelectronics (CADSM'2009), Lviv – Polyana, Ukraine, 2009.

[5] Kebkalo O.S., Mikhaylyuk A.YU., Tarasenko V.P.: Funktsíonal'ní profílí spetsíalízovanikh ínformatsíyno-analítichnikh sistem, Naukoviy vísnik Chernívets'kogo uníversitetu: Zbírnik nauk. prats'. Fízika. Elektroníka, 423/2008, s. 117-123.

[6] Kotov V.Ye.: Seti Petri, Nauka. Glavnaya redaktsiya fiziko-matematicheskoy literatury, 1984.

[7] Lakhutin D.G.: O probleme otsenki poiskovykh sistem, NTI II 1/1970, s. 24-34.

[8] Mikhaylyuk A.Yu., Ognívchuk L.M., Snízhko M.V.: Tekhnologíya vprovadzhennya novítníkh ínformatsíyno-analítichnikh sistem u navchal'niy protses, Materíali Vseukraí̈ns'koí̈ naukovo-praktichnoí̈ konferentsíí̈: Osvíta v ínformatsíynomu suspíl'ství, 2010, s. 56-62.

[9] Mikhaylyuk A.Yu., Snízhko M.V., Bígun L.M.: Pro deyakí napryamki ínformatizatsíí̈ vishchoí̈ osvíti v umovakh s'ogodennya, Vishcha osvíta Ukraí̈ni – Dodatok 4, tom I, 13/2009, s. 457-463.

[10] Piterson D.: Teoriya setey Petri i modelirovaniye sistem, Mir, 1984.

[11] Teslyuk V., Denysyuk P., Hamza Ali Yousef Al Shawabkeh, Kernytskyy A.: Developing Information Model Of The Reachability Graph, Proc. of the XVth International Seminar: Workshop Of Direct And Inverse Problems Of Electromagnetic And Acoustic Wave Theory (DIPED – 2010), Tbilisi, Georgia, 2010, p. 210-214.

[12] Vasilevich L.F., Mikhaylyuk A.Yu., Tarasenko V.P., Teslenko O.K.: Funktsíonal'no-oríêntovaniy pídkhíd do proyektuvannya íntelektual'nikh ínformatsíyno-analítichnikh sistem, Reêstratsíya, zberígannya í obrobka danikh, vol. 12, no 2/2010, p. 128-142.

[13] Vasil'yev V.V., Kuz'muk V.V.: Seti Petri, parallel'nyye algoritmy i modeli mul'tiprotsessornykh sistem, Nauk dumka 1990.

[14] Vasyliuk I., Teslyuk V., Kernytskyy A, Denysyuk P.: Four-layer Model of MEMS Ontology Design, Proc. of the VI-th International Conference of Young Scientists (MEMSTECH'2011), 2011, p. 219-220.

[15] Zelinskyy A., Teslyuk V., Denysyuk P., Medykovskyy M., Struk I.: Data and Software Development for CSP Solution Subsystem during MEMS Design, Proc. of the V-th International Conference of Young Scientists (MEMSTECH'2010), 2010, p. 66.

[16] Zwicky F.: Discovery Invention, Research Through the Morphological Approach. McMillan, 1969.

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